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→ The basic aim of the research proposed for this AFOSR Grant was to investigate, in depth, the optimization of iterative methods for solution of nonsymmetric nonpositive-definite matrix equations which arise in the numerical approximation (by finite difference or finite elements) of typical <i>convection-diffusion problems</i> . In the opinion of this Principal Investigator, the research results obtained, with AFOSR support, were of sufficient quality to be published in leading technical journals. We list below published research papers (each carrying an acknowledgment of AFOSR support), associated in this period with this current research effort. (KR) (—)				
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Dear Mr. Bell:

Enclosed is the Final Technical Report for my AFOSR Grant-85-0245, which ended September 30, 1989.

I apologize for my delay in getting this Report to you, but I have had some personal problems, associated with an aging parent.

Let me take this opportunity to thank you for your support of my research efforts in numerical analysis for 15 years (beginning in 1974 and ending in 1989). It was a surprise for me to find that, on counting the number of research papers of mine which acknowledged AFOSR support, was 72. This amount of research could certainly not have been carried out without your generous support!

Sincerely,

Richard S. Varga

Richard S. Varga
University Professor of Mathematics

RSVgeb

cc: Marilyn A. James
Dr. A. Nachman



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Final Technical Report: AFOSR Grant-85-0245

October, 1987 to September 30, 1989.

Richard S. Varga, Principal Investigator
Kent State University, Kent, OH 44242

The basic aim of the research proposed for this AFOSR Grant was to investigate, in depth, the optimization of iterative methods for solution of nonsymmetric nonpositive-definite matrix equations which arise in the numerical approximation (by finite difference or finite elements) of typical *convection-diffusion problems*. In the opinion of this Principal Investigator, the research results obtained, with AFOSR support, were of sufficient quality to be published in leading technical journals. We list below published research papers (each carrying an acknowledgment of AFOSR support), associated in this period with this current research effort.

Published Research Papers (in Numerical Analysis)

1. M. Eiermann, W. Niethammer, and R.S. Varga, "Iterationsverfahren für nichtlineare Gleichungssysteme und Approximationsmethoden im Komplexen", Jahresbricht der Deutschen Mathematischem Verein. 89(1987), 1-32.
2. M. Eiermann, X. Li, and R.S. Varga, "On hybrid semiiterative methods", SIAM J. Numer. Anal. 26(1989), 152-168.
3. Garry Rodrigue and Richard Varga, "Convergence rate estimates for iterative solutions of the biharmonic equation", J. Comp. Appl. Math. 24(1989), 129-146.
4. Xiezhang Li and Richard S. Varga, "A note on the SSOR and USSOR iterative methods applied to p -cyclic matrices", Numer. Math. 56(1989), 109-121.

In addition, the Principal Investigator carried out research on related analysis and linear algebra problems (i.e., *not* directly on the iterative solution of nonsymmetric nonpositive-definite matrix equations). This was done mostly in the academic-year portions of this

grant period (not covered by this AFOSR grant). As some very minor portions of the summer months (covered by this AFOSR grant) were inevitably spent on the resulting research (such as proof reading, etc.), it was felt that an acknowledgment to AFOSR support was in order. The resulting published papers (carrying an AFOSR acknowledgment) are listed below.

Published Research Papers (in Related Areas)

5. Richard S. Varga, "Scientific computation on some mathematical conjectures", Texas Tech University, Visiting Scholars Program, 1986-1987, 15(1988), 119-136.
6. George Csordas and Richard S. Varga, "Moment inequalities and the Riemann Hypothesis", Constr. Approx. 4(1988), 175-198.
7. P. Olivier, Q.I. Rahman, and R.S. Varga, "On a new proof and sharpenings of a result of Fejér on bounded partial sums", Linear Alg. Appl. 107(1988), 237-251.
8. Arden Ruttan and Richard S. Varga, "A unified theory for real vs. complex rational Chebyshev approximation on an interval", Trans. Amer. Math. Soc. 312(1989), 681-697.
9. George Csordas and Richard S. Varga, "Integral transforms and the Laguerre-Pólya class", Complex Variables 12(1989), 211-230.
10. A.K. Rigler, S.Y. Trimble, and R.S. Varga, "Sharp lower bounds for a generalized Jensen inequality", Rocky Mountain J. of Math. 19(1989), 353-373.
11. Arden Ruttan and Richard S. Varga, "Real vs. complex rational Chebyshev approximation on an interval: $\gamma_{m,m+2} \leq 1/3$ ", Rocky Mountain J. of Math. 19(1989), 375-381.

To summarize the basic research of this AFOSR Grant-85-0245, much has been learned in this two-year period about i) the use of *Faber polynomials* to obtain *asymptotically*

optimal convergence rates for iterative methods applied to nonsymmetric nonpositive-definite matrix equations (such as those arising from discrete approximations to convection-diffusion equations), and ii) the analysis of *hybrid methods*, which have great potential in this same area. The ideas are now very current. For example, at the recent Copper Mountain Conference on Iterative Methods (April 3-5, 1990), organized by T.A. Manteuffel, such ideas (as well as related ones) were very much in evidence. In my invited talk at this Conference, these ideas (Faber polynomials and hybrid methods) were detailed. To this Principal Investigator, these ideas, which make liberal use of complex variable theory, conformal mapping, and complex approximation theory applied to iterative methods, will no doubt be of great interest in *future* developments in this field.